# NASA Facts

National Aeronautics
and Space Administration

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## Digital Mammography – Remote Sensing Technology Provides Examining Room Diagnostics

Space-based instruments that researchers are using to study the atmosphere may soon have a place in the medical examination room. Researchers at NASA Langley Research Center believe that the computers and **C**harge **C**oupled **D**evices (**CCD**s) that worked so well on satellites examining the atmosphere can also be effective in mammograms for the early diagnosis of breast cancer. This transfer of technology is possible because both atmospheric studies and mammography require compact, reliable, low-power sensors and digital computers. The approach may save countless lives in the near future.

### What is a CCD?

A CCD is a compact silicon chip built using the same technology as computer chips. You'll find CCDs in many items, like cameras, camcorders and scanners at the grocery store. The same CCD chip that can replace vacuum tubes the size of coffee cans with something the size of a postage stamp, can also replace x-ray-sensitive film used for mammography. This is done by converting x-rays into light, then into electronic signals; these signals are then changed into images and stored in a computer.

In a similar way, our eyes convert light to nerve impulses that are interpreted by the brain; this is the sense we call sight. The CCD captures an image by recording the pattern created when light, or a photon, strikes the CCD surface; but the process for both is based on the same principle– converting light energy to electrical energy.

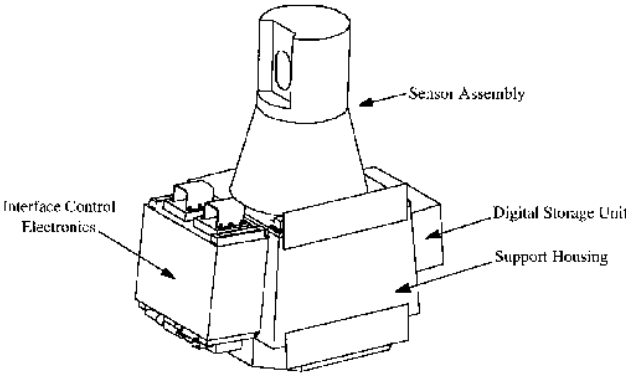
NASA Langley atmospheric scientists have used CCD technology for years in satellite-based experiments that monitor changes in the Earth's atmosphere, including natural events and human activities. The latest in the series is the **S**tratospheric **A**erosol and **G**as **E**xperiment **III** (**SAGE III**). SAGE III will measure ozone in the stratosphere, and examine clouds, temperature, water vapor and other chemical combinations. By monitoring ozone and atmospheric changes, researchers can

### *Do you know these terms?*

***Stratosphere*** *- One of the layers in the Earth's atmosphere, consisting of gases, vapors and suspended matter, including the ozone layer. The stratosphere is about 20 km (19 miles) above sea level and just above the layer where our weather occurs (the troposphere).*

***Ozone*** *- A form of oxygen that is in the Earth's upper atmosphere. It prevents some ultraviolet solar radiation from striking the Earth. If the ozone layer were to thin, more ultraviolet rays would reach the Earth, causing damage to crops and perhaps leading to increased incidence of human skin cancer.*

***Aerosol*** *- A very small liquid or solid particle that is finely dispersed in air. A cloud contains natural aerosols (water droplets). Manufactured aerosols include insecticides, disinfectants and sanitizers, detergents and cleaning compounds, waxes, automotive products and coatings (such as paints and hair sprays). Other aerosols are volcanic ash and smoke.*




**The SAGE III instrument with its CCD arrays and digital computers will monitor the Earth's ozone layer.**

determine the effects of pollution and natural events on global warming and the Earth's environment.

When researchers designed a mammography unit using the CCDs, computers and scanning techniques from SAGE, they came up with one that basically compresses the breasts like conventional, film-based mammography equipment. However, conventional units use film to capture the x-ray images, so not much adjustment is possible to accommodate different tissue density (young women have dense breast tissue; older women do not). The new unit, however, based on SAGE technology, doesn't use film. It uses CCDs to capture the x-ray image electronically and transfer it directly to a computer. The computer can then assist in displaying and inspecting the image. It can even fill in any minor gaps in the image that the CCD edges might miss.

## Electromagnetic energy makes all this possible

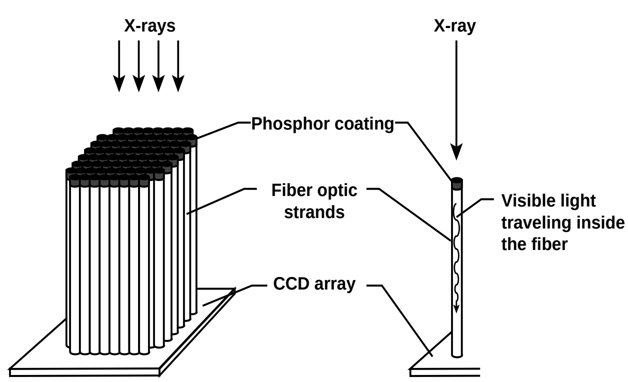
In remote sensing, researchers are concerned with three types of radiation: reflected, absorbed and emitted. This information is collected by instruments on satellites and fed to digital computers which analyze, interpret and evaluate it. In mammography, researchers are interested in x-rays that are partially absorbed or transmitted. After the x-rays pass through solid tissue in our bodies, the pattern they make is collected by the CCD system and fed into a computer so the data can be examined by technicians and specialists.

The same technology that NASA Langley researchers use to study the atmosphere is effective for mammograms because of the electromagnetic spectrum, which is the energy that is radiated through space in the form of electromagnetic waves. When the energy encounters even a very tiny object like a molecule of air, one of three reactions occurs:

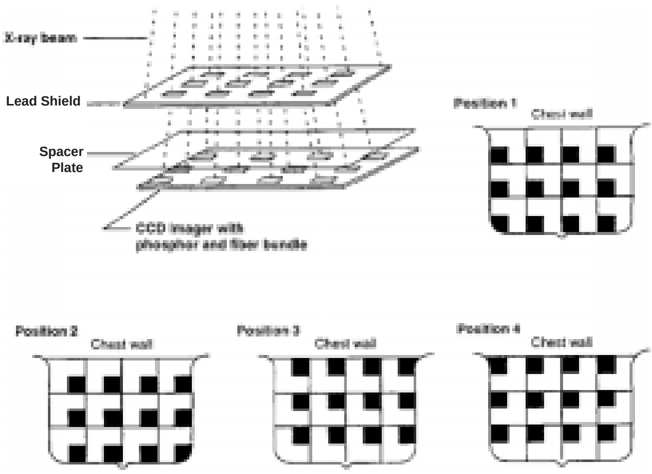
- The radiation will be reflected off the object.
- The radiation will be absorbed or transmitted through the object.
- The radiation will be emitted from the object.

X-rays are invisible to CCDs, so the NASA Langley researchers use a phosphor material that would convert the x-rays into something the CCDs could detect. The phosphor coating is put on one end of many very fine glass rods, or fiber optic strands. The other end of these fiber optic strands was attached to the CCDs. The phosphor lights up when the x-rays hit it and the light passes through the fiber optics to the CCDs. The CCDs see this transmitted light and send the electronic pattern on to the computer.

The researchers put several of these CCD bundles on a kind of a checkerboard that moves




**The phosphor lights up when x-rays hit it; the fiber optic strands transmit that light to the CCDs.**



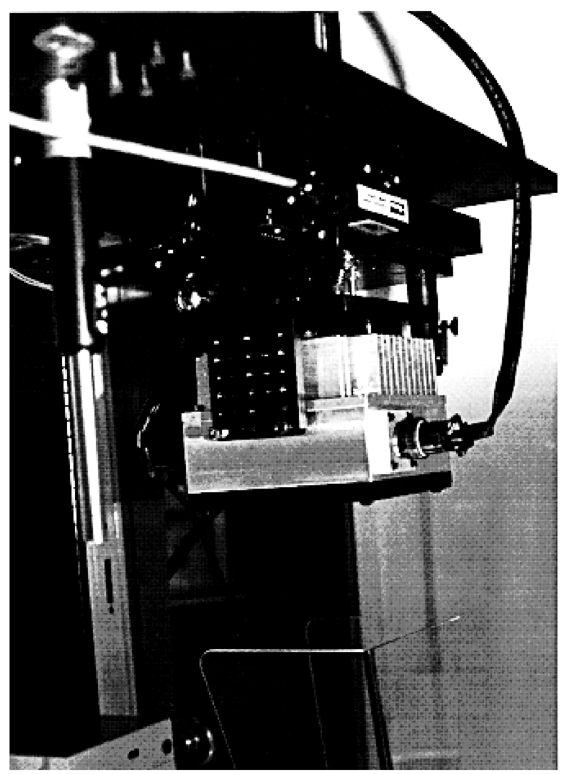

**While the lead shields the patient from excessive x-rays, the CCD arrays move in a square pattern.**

around in a square pattern while x-rays are taken. The woman's breast rests on a spacer above this checkerboard. Over the top of the breast, they created a lead shield that has 25-mm (about 1-inch) holes the same size as the CCD bundles. The solid part of the lead absorbs any x-rays that hit it, just as an apron protects against grease spatters; but the x-rays go right through the holes. Both the lead shield and CCD checkerboard are mounted on a computer-controlled machine with arms to move the CCDs and lead shield simultaneously.

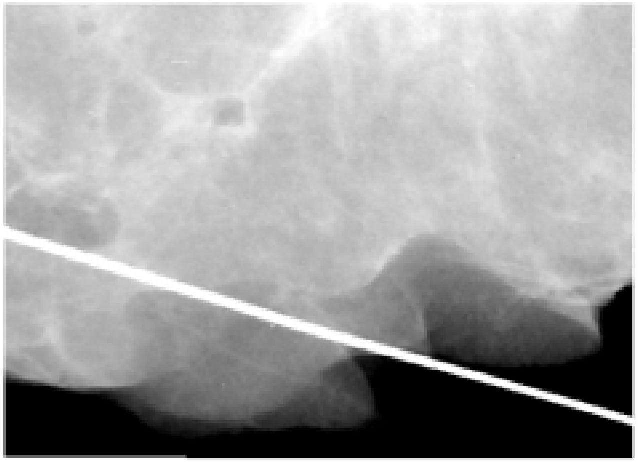
The result is a mammography unit that takes an x-ray, and the CCD bundles capture the image. The machine then moves the checkerboard and lead shield to a second spot, a third and a fourth. The result – four x-rays for a complete CCD image, with each spot of breast tissue receiving only one exposure.

What the researchers devised is essentially a machine that is like an obstacle course for x-rays. The x-rays want to go everywhere, but they are prevented from doing so by the lead shield. Where the shield is solid, the x-rays get absorbed and are out of the race. If they encounter the holes, the x-rays get to continue on their way. Their course then takes the remaining x-rays through the breast, where some get absorbed or transmitted because they encounter tissue and others race on through. The CCD bundles underneath the breast detect the subtle differences between the x-rays that raced straight through and the ones that got absorbed or transmitted before completing their course. The computer records it all for later analysis and diagnosis. The x-ray obstacle course is over and the race to spot any breast cancer now begins.

The Langley approach has many advantages over current mammography techniques. First, it's quick; the CCD arrays can scan one 25-mm spot in less than a second. Within three to five seconds, this process has been repeated three more times and every CCD array has captured a precise image. Second, it's easy; the computer-controlled machine does the work of moving the equipment. Third, it's safe; there's not much chance that the lead shield will slip out of its tightly aligned position because the machine works so well in keeping the layers



**Digital mammography test equipment at NASA Langley.**



**CCD image of a piece of tissue that was removed surgically (biopsy). A needle is at the bottom of the biopsy image.**

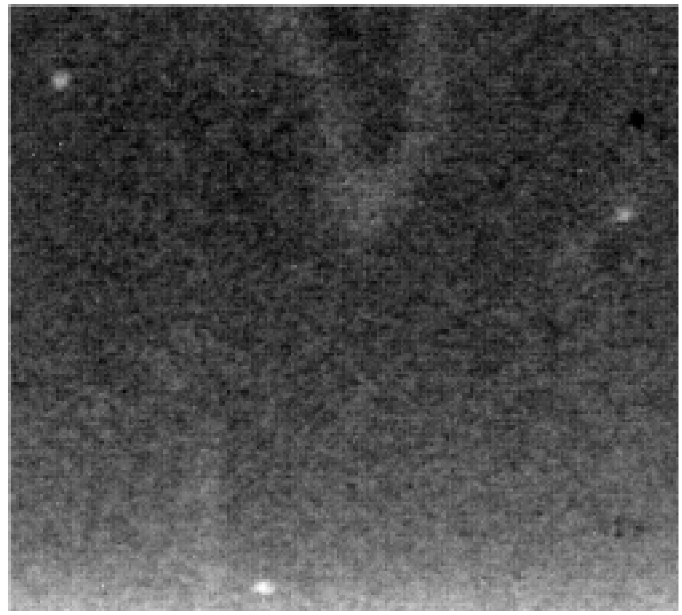
where they belong and in moving the arms after each x-ray exposure. Fourth, in comparison with other digital approaches, this technique allows full breast coverage.

The computer helps even more after the images are taken. It can scan each part of every mammogram image and report any suspicious areas. It can also help make the scans consistent from patient to patient. In addition, electronic images can be transmitted to other experts if more opinions are needed.

## Why the concern about breast cancer and mammograms?

Almost one-fourth of all cancers in women are located in the breast, causing about 20% of all cancer deaths in women. Most of these deaths occur in women between the ages of 50 and 60, although the cancer can start developing years earlier. The sooner a small, unusual growth can be detected, the better the chances for recovery if the tumor is cancerous.

Women are encouraged to give themselves monthly self-examinations to feel for any strange little lumps on or around the breasts. The woman's doctor also performs this examination during periodic checkups. However, by the time the woman or her doctor feels a lump, it may already have spread. If that happens, it's harder to find and remove all the cancerous growth.



**CCD image of a standard test pattern shows simulated tumors that are level 4 on a scale of 1 to 5, with 5 being the hardest to spot.**

That's why the mammogram is so valuable. Properly exposed film mammograms reveal fine detail in the breast; in fact, some have even detected tumors as small as 0.2 mm, about the thickness of a piece of thread. How much better, though, if tumors as small as 0.1 mm could be identified clearly. That's the goal of digital mammography. Thanks to satellite technology, the researchers at NASA Langley may have devised a technique that will achieve that accuracy. If so, NASA researchers will have contributed to saving the lives of countless women using the same technology with which they monitor the atmosphere and help protect the Earth's ozone layer.

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